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Abstract

IRRADIATION TESTS OF UO_2 FUEL: RADIOGRAPHY WITH BETATRON AND NEUTRON; RELOCATION OF FISSION PRODUCTS AND PLUTONIUM

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Natural uranium UO_2 pellets fabricated by the "roll method" were irradiated in GETR at high temperature (specimens S-1, S-2, temperature ~ 2000 °C at the surface and ~ 3000 °C at the center) and at lower temperature (specimens S-3, S-4, temperature ~ 900 °C at the surface and ~ 1500 °C at the center). Each of four sets with six pellets, 12 mm in diameter and 12 mm in length was put in a dual stainless steel capsule and were irradiated for one and two months, at respective temperature. Out of many findings two remarkable results are reported here.

RADIOGRAPHY WITH BETATRON AND NEUTRON

By taking advantage of the penetrating power, low scatter, and extremely fine focus of betatron X-rays, a technique taking clear and high resolving radiographs of a fuel has been developed.

Distance between the film and the specimen was 50 - 100 cm and a steel plate interposed between them. The distance between the film and the betatron focus was 100 - 200 cm. The intensity ratio of betatron X-rays to specimen radiation which determines clearness of radiograph became very

large (e. g. > 1000) as compared with a conventional X-ray radiograph in which film specimen distance was very small and because penetration of 15 MeV X-rays is larger than fuel gamma ray by a factor of 10 with a 7 cm iron plate.

Betatron radiographs of S-1, and S-2 show that the inner capsules were molten down except at both ends, and pellets themselves were united completely into a single rod with a big void along the central axis of the rod. Those of S-3, and S-4 shown that inner capsules were sound and each pellet cracks, especially outer half of the top pellet was severely deteriorated. A neutron radiograph of the specimen by our research reactor TTR - 1 neutron flux also gives a clear image especially of the void. Results of pinhole camera autoradiography of the specimens are far inferior to the above.

It is concluded that betatron radiography is especially effective for non-destructive testing for fuel when it has such high activity as more than several thousand MWD per ton.

RELOCATION OF FISSION PRODUCTS AND PLUTONIUM

The specimens mentioned above, of about 0. 05 % (S-1) and 0. 1 % (S-2) burnups were examined about distribution of fission products (Ce, Ru, Zr-Nb and Kr) and plutonium along the length and also at cross sections of the rods. Distribution of Ce, Pu and Ru were found fairly normal while the concentration of Cs was quite high at both ends of the rod where the temperature was lower than the central part. Zr-Nb was found more concentrated in the inner part. About two percent of Kr-85 was found to be remained in S-1. Distribution of specific activity throughout the rods was quite irregular having wide depleted sections.

On the other hand, the distribution of fission products and Pu in specimens which were irradiated under lower temperature were quite uniform, which suggest that migration of fission products and plutonium should be considered in UO_2 fuel which are irradiated near the melting point.